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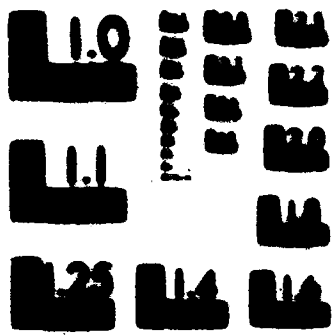
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See reverse.

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A computer-based display system has been designed and built enabling the investigation of the processes underlying spatial localization. Among the results obtained in the past year with the use of this device are: a) Eye movements play a significant role in spatial localization that is not limited to positioning the stimulus array optimally on the retina. b) Neither retinal image drift nor abrupt movement of the retinal image is sufficient to restore normal performance on a localization task when the effects of eye movements on retinal image position are eliminated. c) Preliminary data indicate that localization is a very slow process, much slower than form detection. In related work it has been shown that for some simple forms (sine wave gratings) the relative orientation of the stimuli does not affect ability to detect small differences in their sizes and conversely a difference in size between two stimuli does not affect ability to detect a small difference in their orientations. Further it has been found that the detection of small differences in size between two objects is masked strongly by stimuli consisting of fine lines but not by stimuli consisting of broader lines (high and low spatial frequency gratings respectively). It has also been found that eye movements are essential to the discrimination of objects on the basis of hue change in the yellow region of the spectrum.

AFOSR-TR- 83-0832

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FY-1983 ANNUAL REPORT

# SPATIOTEMPORAL CHARACTERISTICS OF VISUAL LOCALIZATION

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## RESEARCH OBJECTIVES

We are continuing to study the spatial and temporal characteristics of relative spatial localization, seeking to establish conditions in which it can be isolated from those processes underlying the detection of motion and form. In addition to our original ideas, we are also considering the following approaches to enable us to separate the position system from form and motion:

Contrast--

We intend to explore the effects of contrast on relative spatial localization, primarily as a means of identifying the underlying mechanisms. Previous reports that there are (low) stimulus contrasts at which a drifting grating can be seen but appears stationary suggest that the contrast thresholds for form and position are different (just as they often are for form and motion).

Adapting-out the motion system--

To distinguish detection of a change of position from motion-detection we intend to explore the idea of adapting the motion system by prolonged viewing of moving stimuli and then measuring thresholds for detecting the change in location of a target presented sequentially in two positions. The duration of the interval between presentations will be varied. By this technique we should be able to determine the delay between presentations at which a change of position is signaled by the position system and not by the motion system; at this, and all longer durations, the

motion adaptation should not have an effect on threshold.

## STATUS OF RESEARCH

### Development of Laboratory Facilities--

During the first year a general purpose, computer-controlled display system was designed and built. It has been operational since January 1983. Because of our interest in the temporal characteristics of spatial localization, emphasis was placed on having flexible and accurate control of the temporal presentation (and spatial displacement) of the stimuli. We currently have the capability of simultaneously producing four different temporal modulations (controlling more than a dozen parameters of each individually) and three similarly complex (nested or independent) scrolls.

A large field with reasonable resolution was required to study the global effects we are interested in so we chose a 19" (diagonal) raster scan with 512 x 512 elements that runs at a 60 Hz frame rate. The display is driven by an Apple II+ computer via a custom-built digital interface and a custom-built D to A interface that multiplies the pattern by a 12 bit constant (providing the necessary control of contrast for threshold settings) and that also corrects for the non-linearity of the display

We have implemented the method of constant stimuli and a variety of staircase procedures.

The laboratory set-up also includes a Generation III SRI eyetracker and stimulus deflection system.

A 1200-baud modem enables easy communication with our software consultant.

These devices and the laboratory layout are shown in the attached photographs.

__Effects of eye movements in spatial localization__--

Several paradigms were used to study the effects of eye movements on spatial localization. In most experiments the subject's task was to determine whether a target was centered with respect to a frame of reference. The reference frame consisted of 2 horizontal bars. To minimize the use of symmetry and other form cues, the bars were displaced horizontally. The bars were presented at various locations with respect to the screen boundaries, so that the screen itself was not a useful cue. The target was presented at various vertical locations between the two bars. All stimuli used in the experiments reported here are well above the subject's threshold contrast.

Our main findings from these experiments were:

(1) With a stationary frame-target array stabilization of the retinal image impairs but does not severely degrade performance on localization tasks.

(2) This failure of stabilization to have a large effect is not due to luminance transients in the stimulus. There were also only small effects of stabilization when gradual stimulus onsets were used.

(3) This small effect was also not due to the fact that the stimulus was presented at a single location (a "position transient"). When the target was slowly (or abruptly) drifted into its test position, there was still only a small effect of stabilization.

We then simulated the effects of natural eye movements on retinal image motion by scrolling the entire array vertically--simulating drifts--or by moving the array abruptly to a new location--simulating fixation saccades. The results of these stimulus manipulations were similar under stabilized as under unstabilized viewing conditions, and none of the manipulations had substantial effects. Normal ability to localize was not restored as long as the effects of eye movements on retinal image position were eliminated. That the imposed retinal image motion fails to return performance to normal in the stabilized case stands in sharp opposition to the restorative effect a small amount of image motion has on contrast thresholds.

<u>Temporal characteristics of spatial localization</u>

We have begun a parametric study of the temporal characteristics of spatial localization, using the paradigm described above in which a target is centered between two offset bars. We are varying the duration of the stimulus presentation and measuring minimum discriminable, static target offset. We are also examining the effects of stimulus contrast, but intend to remain in the suprathreshold contrast range unless preliminary data suggest otherwise. Thus far we have found localization performance remarkably accurate at presentation times as low as 33 msec. We also find that increasing the contrast can improve performance, even though the stimulus is clearly visible at lower contrasts. Degradations

in performance on localization tasks can be seen at contrasts and durations for which the test stimulus is clearly detectable: this fact facilitates separation of the process underlying localization from that underlying detection.

<u>Representing the two dimensional aspects of form--in collaboration with Dr. D. Regan, Dalhousie University</u>.

A currently popular idea is that the form of objects is encoded in channels that are tuned to specific spatial frequencies and orientations: each channel is presumed to have a preferred spatial frequency and orientation  the channels collectively cover the entire range of orientations and detectable spatial frequencies; and the channels operate independently  Although there is some support for this idea at threshold contrast levels, it has not been tested well at suprathreshold contrasts.

We examined the characteristics of the mechanisms responsible for discrimination between suprathreshold objects by measuring spatial frequency and orientation discrimination in several conditions. First we determined if spatial frequency discrimination depended on the orientations of the gratings being compared. A reasonable prediction of channel models is that spatial frequency discrimination will be severely degraded if the orientations of the gratings being compared are very different. We found that even when the gratings were orthogonal, discriminability was not impaired. The same result was obtained for a range of spatial frequencies.

We also assessed the effect of spatial frequency differences on orientation discrimination. Again, channel models would predict substantial degradation. However, we found that discrimination was unimpaired when the gratings being compared differed in spatial frequency by more than an octave.

<u>Mechanisms underlying spatial discrimination--collaboration with Dr. D. Regan, Dalhousie University</u>.

We used a masking paradigm to explore further the interconnections between the subunits involved in spatial discriminations.

To determine if spatial frequency information was pooled across orientations at the discrimination stage, as suggested by our earlier work, we measured spatial frequency discrimination in the presence of an orthogonal masking grating. We found that when local cues to frequency (the shape of the small rectangles formed by the orthogonal gratings) were eliminated, an orthogonal mask had little effect on discriminability.

However, masking by parallel gratings had large effects and these effects are asymmetric: higher spatial frequencies mask lower ones much more than lower ones mask higher ones. These results are only evident if cues arising from local spatial interactions between the test and mask are eliminated (by small random perturbations of the mask frequency). If such cues are not eliminated masking appears to have its largest effect near the test frequency (where the difference between the

beat frequencies is much more obvious than is the difference between the test frequencies), and the effect is facilitation not degradation of discrimination.

<u>Determining the essential aspects of eye movements in a discrimination task—in collaboration with Dr. D. Regan, Dalhousie University.</u>

When the effects of eye movements on retinal image position are eliminated, some visual information is lost. What is the nature of this loss, and what temporal modulation of the retinal image is sufficient to restore normal or nearly normal discriminability of two objects?

We measured the effects of stabilizing the retinal image on a subject's ability to discriminate between two fields which differed only in hue. Discriminability was severely degraded in all except the yellow region.

We then oscillated the fields laterally and luminance-flickered them to determine if either of these artificial forms of temporal modulation could restore the normal percept. We found that both conditions returned discriminability to near normal conditions.

These results show that scanning eye movements are not necessary for normal discriminability of two objects that differ only in hue, but that some temporal modulation of the retinal input is essential.

PUBLICATIONS

"Independence of orientation and size in spatial discriminations", with D. Regan submitted to J. Opt. Soc. Am.

"Temporal characteristics of global spatial localization", C.A. Burbeck, J. Opt. Soc. Am., in preparation.

"The role of eye movements in global spatial localization", C.A. Burbeck, J. Opt. Soc. Am., in preparation.

"Masking of spatial frequency discriminations" with D. Regan, J. Opt. Soc. Am., in preparation.

"Temporal factors in color discrimination" with D. Regan, J. Opt. Soc. Am., in preparation.

5. Professional Personnel:

C. A. Burbeck

6. Spoken papers:

"Second Thoughts about Channels", AFOSR Workshop on "Models of Visual Processing", Sarasota, Fla, May, 1983.

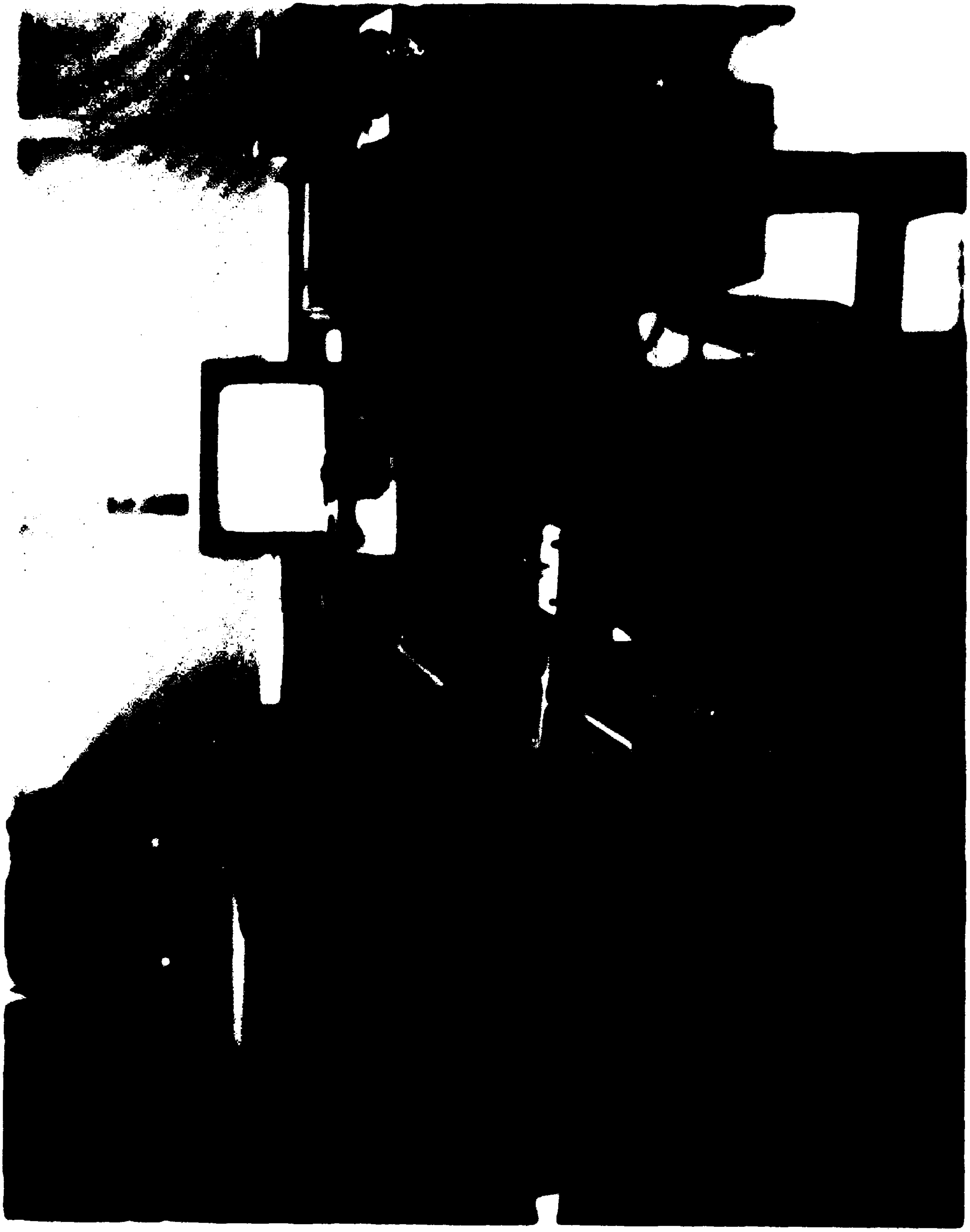
"Temporal factors in color discrimination" with D. Regan, Assoc. for Research in Vision and Ophthalmology Sarasota, Fla., May 1983.

7. New discoveries and specific applications.

a. We have found that eye movements play a small but significant role in global spatial localisation even when the stimulus array is optimally located on the retina. Consequently, if precise localisation is not required eye movements can be made optimal for other tasks. However, if localisation must be acute, free scanning is essential for optimal performance.

b. We have found that global spatial localization is a relatively slow process: objects can be accurately identified without being precisely located. Consequently, in visual tasks in which localization is important longer presentation times are essential for optimum performance; it is not sufficient for the object merely to be detected for accurate localisation.

c. The independence of the visual subprocesses responsible for encoding size and orientation that we have demonstrated implies that in visual displays these two stimulus features can be used to represent independent parameters without confusion to the observer.



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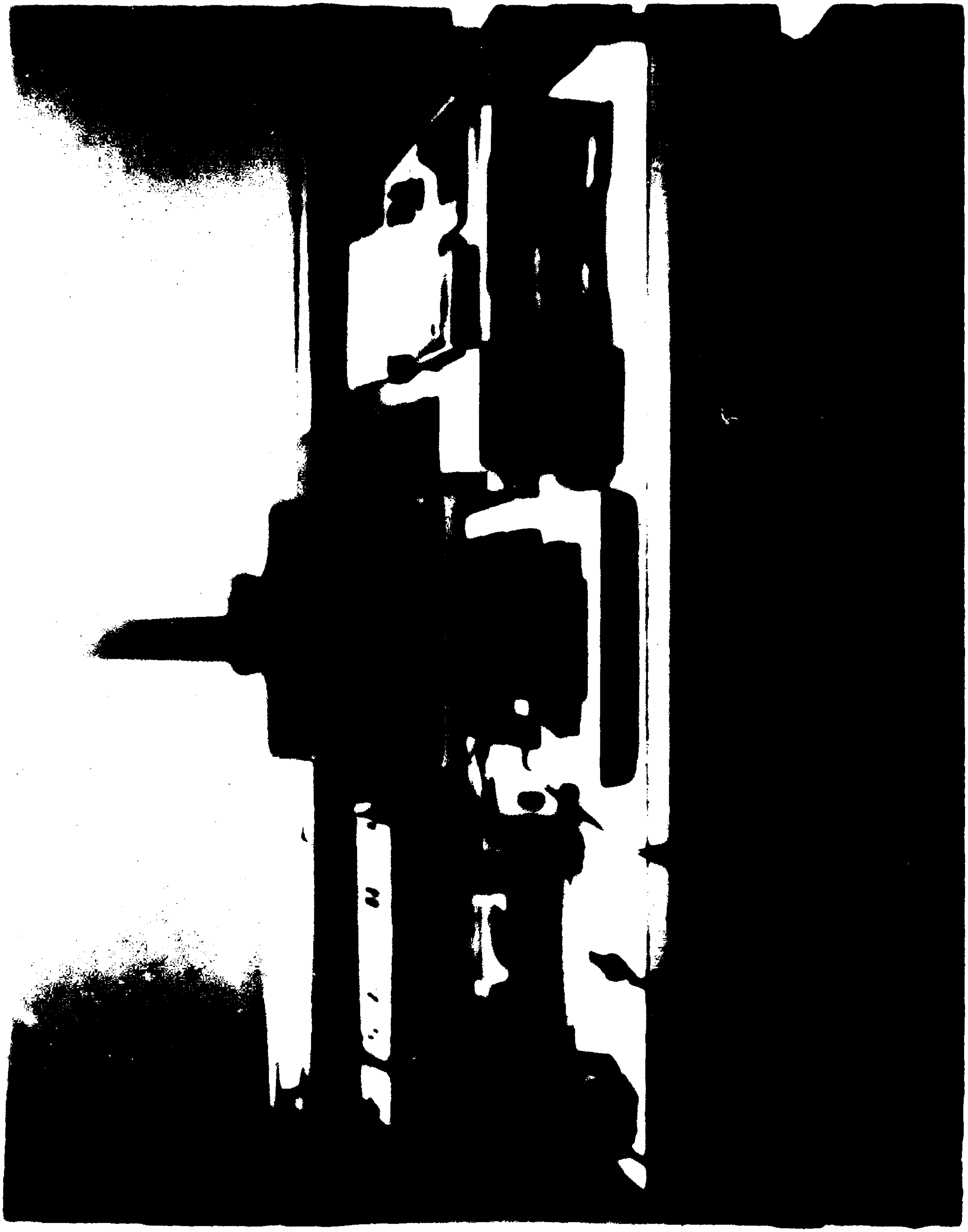

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